CLAIMS

What is claimed is:

1. An implantable medical device with a plasma-modified surface, comprising:

a structure adapted for implantation into a patient, the structure comprising at least one contacting surface for contacting a bodily fluid or tissue, wherein the contacting surface is modified by plasma treatment in a plasma comprising nitrogen-containing molecules and oxygen-containing molecules and by a biologically compatible coating.

2. The device of claim 1, wherein the nitrogen-containing molecules are molecules selected from the group consisting of NH_3, $(NH_4)^+$, N_2O, NO, NO_2 and N_2O_4.

3. The device of claim 1, wherein the oxygen-containing molecules are molecules selected from the group consisting of O_2 and O_3.

4. The device of claim 1, wherein the plasma treatment with the nitrogen-containing molecules and the oxygen-containing molecules is sequential.

5. The device of claim 1, wherein the plasma treatment is for less than about two minutes.

6. The device of claim 5, wherein the plasma treatment is for between about thirty seconds and about one minute.

7. The device of claim 1, wherein the plasma treatment is of a plasma wherein the nitrogen-containing molecules are NH_3 and the oxygen-containing molecules are O_2.

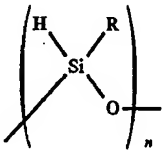
8. The device of claim 1, wherein the plasma treatment is of a plasma wherein the nitrogen-containing molecules are N_2O and the oxygen-containing molecules are O_2.

9. The device of claim 1, where the device is a member selected from the group consisting of stents, catheters, balloons, shunts, grafts, valves, pacemakers, pulse generators, cardiac defibrillators, spinal stimulators, brain stimulators, sacral nerve stimulators, leads, inducers, sensors, seeds, screws, anchors, anti-adhesion sheets, plates and joints.

10. The device of claim 1, wherein the at least one contacting surface comprises a metallic material.

11. The device of claim 1, wherein the at least one contacting surface comprises a polymeric material.

12. The device of claim 1, wherein the biologically compatible coating is a membrane formed from the plasma polymerization of a hydrocyclosiloxane monomer of the general formula:



wherein R is an aliphatic group having 1 to about 5 carbon atoms and n is an integer from 2 to about 10.

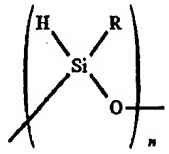
13. The device of claim 12, wherein the hydrocyclosiloxane monomer is selected from the group consisting of 1,3,5,7-tetramethylhydrocyclotetrasiloxane, 1,3,5,7,9-pentamethylhydrocyclopentasiloxane, 1,3,5,7,9,11-hexamethylhydrocyclohexasiloxane, and a mixture of 1,3,5,7,9-pentamethylcyclopentasiloxane and 1,3,5,7,11-hexamethylcyclohexasiloxane monomers.

14. The device of claim 1 wherein the biologically compatible coating is a polymer or co-polymer selected from the group consisting of poly acrylate, poly bisphenol A carbonate, polybutadiene, polycarbonate, poly butylene terephthalate, poly butryl methacrylate, polydimethyl siloxane, polyester, polyethyleneimine, poly methyl methacrylate, polypropylene, polystyrene, polysulfone, polyurethane, poly vinyl, poly vinyl acetate polylactide, polyglycolide, polycaprolactone, and polyvinylidine fluoride.

15. A coating for an implantable medical device with at least one contacting surface for contacting a bodily fluid or tissue, comprising:

the product of plasma treatment of a plasma comprising nitrogen-containing molecules and oxygen-containing molecules; and

the product of plasma polymerization of a hydrocyclosiloxane monomer of the general formula:

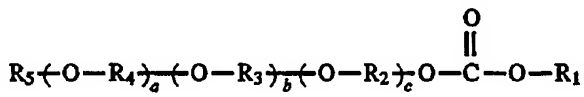


wherein R is an aliphatic group having 1 to about 5 carbon atoms and n is an integer from 2 to about 10.

16. The coating of claim 15, wherein the hydrocyclosiloxane monomer is selected from the group consisting of 1,3,5,7-tetramethylhydrocyclotetrasiloxane, 1,3,5,7,9-pentamethylhydrocyclopentasiloxane, 1,3,5,7,9,11-hexamethylhydrocyclohexasiloxane, and a mixture of 1,3,5,7,9-pentamethylcyclopentasiloxane and 1,3,5,7,11-hexamethylcyclohexasiloxane monomers.

17. The coating of claim 15, further comprising the product of plasma polymerization of a monomer selected from the group consisting of fluorocarbon monomers, organo-based monomers selected from the group consisting of ethylene, allylamine, N-trimethylsilyl-allylamine, hydrocarbons, N-protected unsaturated amines, N-unprotected unsaturated amines, N-protected cyclic aliphatic amines, N-unprotected cyclic aliphatic amines, mercaptans, nitriles and organophosphorus compounds; and functionalizing monomers selected from the group consisting of N_2, CO_2, NH_3 and SO_2.

18. The coating of claim 17, further comprising a polyoxyalkylene tether of the formula:



wherein R_1 is selected from an N-benzotriazole group, an N-2-pyrrolidinone group, or an 2-oxypyrimidine group; R_2, R_3 and R_4 are independently selected alkylene groups of about 2 to about 3 carbon atoms and may be the same or different; R_5 is selected from hydrogen, methyl, a carbonyloxy-N-benzotriazole group, a carbonyloxy-N-2-pyrrolidinone group, and a carbonyl-2-oxypyrimidine group; a is an integer from 1 to 1000 and each of b and c is an integer from 0 to 1000, where a+b+c is an integer from 3 to 1000, under conditions whereby the R_5 group reacts with a free amino group of the third layer thereby forming a covalent bond to give a modified polymeric surface having activated polyoxyalkylene groups covalently bonded thereto.

19. The coating of claim 15, wherein the nitrogen-containing molecules are molecules selected from the group consisting of NH_3, $(NH_4)^+$, N_2O, NO, NO_2 and N_2O_4.

20. The coating of claim 15, wherein the oxygen-containing molecules are molecules selected from the group consisting of O_2 and O_3.

21. The coating of claim 15, wherein the plasma treatment is of a plasma wherein the nitrogen-containing molecules are NH_3 and the oxygen-containing molecules are O_2.

22. The coating of claim 15, wherein the plasma treatment is with a plasma wherein the nitrogen-containing molecules are N_2O and the oxygen-containing molecules are O_2.

23. An implantable medical device with at least one contacting surface for contacting a bodily fluid or tissue, wherein the contacting surface comprises a coating of claim 15.

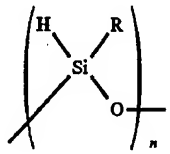
24. The device of claim 23, where the device is a member selected from the group consisting of stents, catheters, balloons, shunts, grafts, valves, pacemakers, pulse generators, cardiac defibrillators, spinal stimulators, brain stimulators, sacral nerve stimulators, leads, inducers, sensors, seeds, screws, anchors, anti-adhesion sheets, plates and joints.

25. A method of imparting bioactive properties to a surface, comprising:

modifying the surface by plasma treatment of a plasma comprising nitrogen-containing molecules and oxygen-containing molecules; and

applying a biologically compatible coating to the surface.

26. The method of claim 25, wherein applying the biologically compatible coating comprises plasma polymerization of a hydrocyclosiloxane monomer of the general formula:



wherein R is an aliphatic group having 1 to about 5 carbon atoms and n is an integer from 2 to about 10.

27. The method of claim 26, wherein the hydrocyclosiloxane monomer is selected from the group consisting of 1,3,5,7-tetramethylhydrocyclotetrasiloxane, 1,3,5,7,9-pentamethylhydrocyclopentasiloxane, 1,3,5,7,9,11-hexamethylhydrocyclohexasiloxane, and a mixture of 1,3,5,7,9-pentamethylcyclopentasiloxane and 1,3,5,7,11-hexamethylcyclohexasiloxane monomers.

28. The method of claim 25, wherein the biologically compatible coating is a polymer or co-polymer selected from the group consisting of poly acrylate, poly bisphenol A carbonate, polybutadiene, polycarbonate, poly butylene terephthalate, poly butryl methacrylate, polydimethyl siloxane, polyester, polyethyleneimine, poly methyl methacrylate, polypropylene, polystyrene, polysulfone, polyurethane, poly vinyl, poly vinyl acetate and polyvinyledine fluoride.

29. The method of claim 25, wherein the nitrogen-containing molecules are molecules selected from the group consisting of NH_3, $(NH_4)^+$, N_2O, NO, NO_2 and N_2O_4.

30. The method of claim 25, wherein the oxygen-containing molecules are selected from the group consisting of O_2 and O_3.

31. The method of claim 25, wherein the plasma treatment with the nitrogen-containing molecules and the oxygen-containing molecules is sequential.

32. The method of claim 31, wherein the plasma treatment is for less than about two minutes.

33. The method of claim 32, wherein the plasma treatment is for between about thirty seconds and about one minute.

34. The method of claim 25, wherein the plasma treatment is of a plasma wherein the nitrogen-containing molecules are NH_3 and the oxygen-containing molecules are O_2.

35. The method of claim 25, wherein the plasma treatment is with a plasma wherein the nitrogen-containing molecules are N_2O and the oxygen-containing molecules are O_2.